Seed Selection - Variables to Consider

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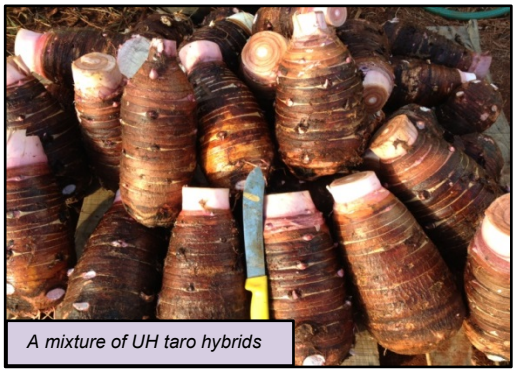
Seeds keep traveling until they find a good place to settle down, and put down some roots. They become adapted to Hawaii through natural selection; the local environment will favor certain characteristics over another, and this will be expressed by the plant under certain conditions. By growing these seeds for generations, they will slowly adapt to our specific location and environmental conditions.

Selecting plants for future generations of seed also involves holding on to the good traits, and getting rid of the bad ones without losing any of the good traits in the process. Sounds straightforward, but it's easier said than done. What seems like something simple can get very complex, especially for a lay person with limited knowledge of plant genetics, but common sense can get you to a good level of proficiency. The main reason is every time you select FOR something, you're selecting AWAY from something. What are we selecting away from? You may not know.

Sometimes, it's selecting yin or yang, and at other times we end up with both. In genetics, sometime good genes are closely linked with bad ones, and these linkages are hard to break. A good example is the Mi gene for root-knot nematode resistance in tomatoes. It's closely linked to the gene for fruit cracking. What's the use of having a nematode-resistant tomato that cracks a lot? Some breeders have spent a lifetime working on this, while others have given up breeding for nematode resistance, instead concentrating on other breeding priorities, and promoting the idea of grafting resistant rootstock onto tomatoes with high quality fruit.

There are divergent attitudes regarding seed selection priorities, and it comes down to the purpose of your seed selection and its end use. Growing for home use is different than selling at the farmer's market, which is different from selling to a wholesaler. When selling to a wholesaler, shelf life and ability to handle transportation between islands is important. For the farmer's market, you can focus more on taste and appearance, and forget about long shelf life.



A mixture of UH taro hybrids

For an organic or home gardener, your priorities are very different from a commercial grower. Taste, tenderness, long harvesting season, adaptability, and resistance to common diseases are important, and uniformity is not. Select from a broad gene pool to maintain diversity, so when a new disease comes your way you should already have the genetics required to impart some tolerance in your crop. But you still want to get rid of some of the bad or wild traits, such as tillering in corn or runners in taro. Rarely do you select a single plant as the next generation, unless you're trying to select a mutation such as a dwarf characteristic, variegation or a special color trait.

Propagating a tissue culture-created taro mutation – Pi'i Ali'i

There are few places in the world that even come close to our climate. Matching the seed with the climate is the key, but that means testing seed from around the globe. One way of speeding up the process is by predicting which seed from which area of the world will do best here to cut down on the varieties you would have to test. In most instances, you're growing a fruit or a vegetable that didn't originate in Hawaii, so it has to adjust to the many variables of this foreign environment.

There are so many variables, including genetics, temperature, day length, soil type and composition, solar radiation, seasons, climate, and within each variables, additional variables. Temperature, for example, will include seasonal differences, range (night low to day high), and cumulative, referred in some crops as degree-days. When I fly from Honolulu to Molokai, and get off the plane, I can feel the difference; cooler and windier with cleaner air. Each island is slightly different, and within each island, there are many micro-climates.

Understanding where the crop originated will give you some indication of its ideal weather. Garlic is native to a crescent encompassing the mountainous foothills of three mountain ranges from Iran to China, the southern parts of the former Russian republics, and also Afghanistan, Pakistan, and India. This area has some of the harshest weather with extremely dry summers and bitter cold winters. However, these plants were carried with man and moved in all directions where they were domesticated. Those domesticated in warmer weather such as the Mediterranean, India, and Southeast Asia would probably fare better in our climate. A good start would be to grow soft neck types from Spain and Italy.

The Russian geneticist N. I. Vavilov identified the centers of origin of crop plants. They include Chinese, Indian, Indo-Malaysian, Central Asiatic, Near-Eastern, Mediterranean, Abyssinian, South Mexican and central American, South American (Peruvian,-Ecuadorian-Bolivian), Chiloe, and Brazilian-Paraguayan. All of our crops come from one or more of these areas. It's interesting that most of these areas are in the tropics, so most plants have genes for these conditions. Maybe it has to do with allowing the genes to express themselves when exposed to our environments in Hawaii.

Some crops will have a very difficult time growing here, and may be adapted to only certain seasons and in some cases, only in certain places. The temperature differential is important for flowering, and the wider the range, the more ideal. When you have a small differential between day and night temperatures, some species cannot 'sleep' at night to build up carbohydrates, and can stress out likened to hyperventilating. This is one of the characteristics of our tropical climate, especially in the summer. However, some varieties domesticated in temperate weather can be selected for your specific conditions. Probably way back when, one of its great-grandparents came from a warmer climate and they have these genes in them.

Taro, for example, exhibit a genetic anomaly called 'transgressive segregation' where individuals in a cross show characteristics unlike their parents. This characteristic has

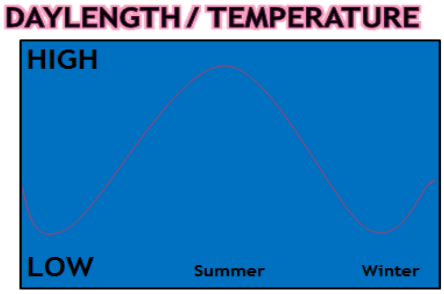
evolutionary implications leading to the creation of new races or species. This characteristic allows plants to occupy new niches or better compete in existing niches. It can also allow plant breeders to find resistance to diseases where none existed in parents and progeny.

When we select plants for our farm, we need to understand what our results mean. If you find a variety that grows well in your farm, all you can say now is “this variety grew well in this place under this cultural management, in this year when planted at this time and harvested at this time.” That’s all! If you start planting it at different times of year, then you can add to your track record of this variety. That’s why we test crops in many areas of this state. We have over 140 soil types. Overlay this with climate and rainfall, and you have a lot of variables, probably more than anywhere else in the world!

Kauwela (right), in a variety trial – Summer 2012

I recently planted a lettuce developed in Hawaii over 60 years ago, but was lost until recently. Kauwela is a bolt-tolerant lettuce and is a sister line to Anuenue. When planted in Hoolehua in the heat of summer, it excelled and was the most bolt-tolerant of over 10 other lettuces bred in Oregon. I gave seed to Nancy and it didn’t do well in Kawanui. I gave some to Russell to plant in Hilo, and it came up with tipburn, a physiological problem connected to calcium deficiency, high temperatures, water stress, and high nitrogen. Any of these can trigger this problem, which manifests itself as brown necrotic spots on the edge of leaves. I suspect it may have growing in a greenhouse with high temperatures. Kauwela was developed for lowland lettuce production and is a cross of between Green Mignonette or Manoa with Great Lakes, one of the grand-daddys of head lettuce. By adding the head lettuce blood to Manoa, you add weight and substance to a small, light, tender, sweet lettuce.

In Hawaii, our longest day is 14 hours and our shortest day is 12. In a crop such as onions, this is critical in selecting what type to grow. There are three classes of onions based on the length of day that triggers them to form a bulb, which include short, intermediate, and long-day onions. Within each class, there are early, medium, and late types. In Hawaii, all short-day and some of the intermediates, especially the early intermediates, will form bulbs. You can plant a field of short-day onions, with rows of early, medium, and late all at one time, and you can harvest over a 1 ½ to 2 month period.



We have been running trials to see how far we can go with intermediate onions, and it appears that the early ones do best and the medium ones are iffy. Long-day onions will not form bulbs in Hawaii, including Walla Walla and the hard storage types bred for the northern states. These have been crossed with green onions because they won’t form bulbs in our climate. The Granex and Grano types are the preferred onion for Hawaii. A virus,

Iris Yellows is raising havoc on onion production and seed production. This means all onion varieties will be selected for tolerance to this virus and away from other traits important to us, such as sweetness, single centers, and others.

What affects taste or sweetness? The key is to understand to what degree the different variables affect taste. In carrots, I used to think that the composition of our soil affects taste, but it turns out the biggest factor is genetics. One of the best tasting carrots is Red Cored Chantenay. Carrots have a compound called terpenoids (think turpentine) that affect taste, but many of these compounds are also anti-oxidants, so it's always a tossup. Can you sell a bad tasting carrot high in anti-oxidants? Probably not! Testing the different carrot varieties for taste would be an important step in selection. What about breeding for varieties that don't have forked roots? This is a function of nutrition. High nitrogen at planting can create forked roots and lots of root hairs. Root-knot nematodes can also create forked roots. Due to the kinds of shallow, heavy soils in Hawaii, we will probably have to grow short, stubby carrots with a really good taste.

Leaf Lettuce - Leopard

Selecting for earliness seems straightforward and simple. Are you selecting for earliness or early bolting or flowering? In lettuce, this is a challenge. What is the ultimate size for a given lettuce variety? It's OK to harvest lettuce early, but not late due to the accumulation of milk. The Latin name for lettuce is Lactuca or milky. Lettuce has many species and is adapted to many climates, but which ones are adapted to the tropics? The most heat tolerant varieties include Manoa, Rex, Ostinata, and others. By starting with heat-tolerant varieties we can develop tropical strains. The French have developed Batavian or Summer Crisp strains that have done well in Hawaii, including Sierra, Nevada, Magenta, Tahoe, Concept, and others. Lettuce is probably the most important crop we should be focusing on expanding because we import several millions pounds annually.

So what is the selection strategy? First, what is your most important priority? If you farm in the lowlands, heat-tolerance would be important, while those in the uplands may look at disease resistance. It costs a lot of money to control disease, so disease tolerance or resistance is important. If you're growing for home use, taste is always important as well as year-round adaptability to your farm. It could even be insect tolerance, and in many instances it may be physical resistance, such as hairiness. This is true for tomato. A wild tomato species, Lycopersicon hirsutum was used to increase hairiness in the tomato plant, which imparted resistance to spider mites.

What about good germination? This appears to be a function of genetics, but other variables come into play similar to flowering. Carrots have germination problems inherent in the genetics, which is why some farmers recommend that you plant some radishes with them to mark the row. This slow germination will also give the weeds a jump on the season. Carrots cannot

handle weed competition as well as other crops with large leaves that create a canopy over the plant.


Carrots – Cosmic Purple

Healthy plants produce healthy seed. This starts with an understanding of each plant's needs, wants, and concerns. Carrots don't like root knot nematodes, so planting after a nematode-resistant cover crop such as sunn hemp or sorghum-sudan grass or even a long fallow will do it. After harvesting carrots, what do you plant? Probably a nematode-resistant crop such as corn or nematode-resistant tomatoes or beans, or even a cover crop. What about color? The first carrots weren't orange. It was the Dutch who pioneered orange carrots because it was their national color. Purple, red, yellow, and white carrots were more common, and are now starting to make a comeback.

If you're a market farmer, yield will always be important. What affects yield? Happy plants with good genetics. What does that mean? Good environment, moisture balance, ideal weather for that species, and adequate nutrition for the system employed. Many plants are developed for high input systems, and will not grow well in low input systems. Luckily, within most inbred lines, there's a lot of select from, one of which is importing more wild traits.

For me, a late maturing variety with a large root system will impart heat-tolerance and stress tolerance, and create a variety that can produce over a longer period of time. I call these sustainable varieties, and they will probably need less fertilizer because they can scavenge from a larger area. The idea of wider spacing is a new concept in high-yield, high-input America. Gone are the cheap fertilizers, so now we have to make a lot of compost to catch up, and this usually means bringing inputs from off the farm unless you have a large area to work with. Deep rooted crops can help you bring nutrients from deep in the ground to the surface for recycling, and all of this has to be worked into your farm plan.

Again, most varieties are developed for cold-tolerance and earliness, so we have to take these seeds, expose them to their new home, and select the characteristics we want. This usually means growing a lot of plants, say 50 or more. The more the merrier. I have a friend who grows orchids in Lualualei Valley on the west side of Oahu. He could spend a lot of time breeding new varieties, but chooses to select new cultivars within his plants instead. He will grow 10,000 plants, even clones, and select the odd balls. In a group of orange epidendrons, he might find a red one. He says this is much easier because he knows how to grow them. In a cross, it might require a whole new set of cultural management techniques, and this might take years to figure out.

How does soil status affect seed selection? If your soil is not well balanced, you will select for plants that can adapt to this imbalance. The ideal pH of most plants is a range of 5.5 to 6.5. If your soil is acidic, some of the nutrients may be toxic to your plants, especially Aluminum and Manganese. Some plants cannot handle these toxic substances and roots will stop dead when they get in contact with these elements and compounds. Make sure your soil is 'in the zone'.

The ideal time to grow for seed is when they can dry in the field, but that would mean only selecting for one season. One strategy would be to grow the most seeds that can be harvested in summer months, but still grow some in other seasons. Try growing all your selections at one time of year to see if your selections made a difference. 'Imposing the environment' on your seeds is important. If you baby them, then the selections you make will always have to be babied. Toughen them up, then select, and the ones you select will be tough, but hopefully not tough to digest. What kind of environment do you want them to be adapted to? You create this situation, then make your selections, and do this for every season, spring, summer, fall, and winter, and also the in-between seasons.

Hybridization can used to implement many strategies. They include introducing wild genes for disease resistance, tolerance to stress, salt-tolerance, specific nutrients or antioxidants, or even increased nutrient use efficiency. Another is increasing the diversity of a crop, and this is done by crossing two different varieties, then planting the seeds for a couple of generations. The first generation will be uniform, but when you plant these seeds, the progeny will resemble each parent, and everything in between.

A good example is a Kale variety called Lacinato Rainbow (left). This is a cross of Lacinato, also known as Toscano or dinosaur kale, and Redbor, a frilly, dark red-purple variety. The cross created a lot of diversity in color, leaf shape, taste, and also adaptability to hot climates. Lacinato is the most heat tolerant of the kales, while Redbor imparts it red and purple color, and possibly increased antioxidants from its purple color. You can select the leaf and color type to increase for the next generation or you can maintain its diversity, and have a lot of different kinds of kale leaf to sell from one variety.

Ploidy is an important concept in plant breeding and is used to create stronger larger plants. A diploid is the standard, with one chromosome from each parent. A tetraploid will have two chromosomes from each parent, and for some reason will be more robust and larger than diploids. Growers will watch for these kinds of plants, especially in orchid production in Hawaii. By crossing a diploid with a tetraploid, you can create a triploid, which will have an incomplete set of chromosomes, with two chromosomes from one parent and only one from another.

In most instances, triploids will be infertile, and will focus their energies on growth and not seed production. A diploid watermelon crossed with a tetraploid one will create a triploid, which will be seedless. Again triploid plants will be strong and robust. The development of triploids in flowers will prevent others from using your plants for breeding. The only way of determining the ploidy of plants is to count the chromosomes, and this requires high magnification microscopes.

Seed selection can be as simple or as complicated as you want to make it. Probably the best way to start is to keep it simple and select for a couple of traits that are important to your farm and your future.